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Potential target reference points that consider fisheries across the extent of the stock: yellowfin fisheries as an example

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Graham Pilling[1], Shelton Harley[1], and Laura Tremblay-Boyer[2]

[1]Secretariat of the Pacific Community, Noumea, New Caledonia
[2]Fisheries Centre, University of British Columbia, Canada

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Overview:

The purpose of this paper is to take one of the biological management objectives suggested at MOW1 for the tropical longline and purse seine fisheries – maintaining yellowfin and bigeye biomass above levels that provide fishery sustainability throughout their range – and provide an example of how it could be made operational to help negotiate and determine Target Reference Points (TRPs) for a stock.

In this example we identify the yellowfin stock sizes associated with 'good' CPUE in longline fisheries in temperate regions of the WCPO. We used these stock sizes to act as potential target TRPs consistent with a management objective of 'maintaining the fisheries across the historical geographic range of the stock'.

Noting that the 'strawman' document states that "Range contractions of yellowfin and bigeye would have serious implications, particularly for SIDs based fleets", we identify the conditions within relevant fisheries that would rebuild stock sizes to those target levels within relatively short timescales, and examine the potential consequences for tropical and temperate fisheries.

The paper should stimulate discussion on a range of matters including the overall management objective, the appropriate timescales for stock rebuild, and consideration of the potential implications for the different fisheries exploiting yellowfin tuna.

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Approach:

In this example, we examined geographic patterns of yellowfin tuna catch rates in the WCPO. These were modelled using aggregate longline catch rate data at a 5° by 5° scale over the last 30 years, accounting for changes in oceanography and the spatial and temporal variability in the catch rate data. This approach provided estimates of the geographic distribution and level of yellowfin catch rates over time. For geographic areas where data from fisheries were absent, the approach estimated the catch rates that would have resulted had fishing occurred. For the current study:

- model CPUE estimates were used to identify potential 'minimum' catch rate thresholds around the southern WCPO region that could be considered as suitable fishery management objectives;
- the time period at which those minimum catch rates were last seen in the southern WCPO region were identified;
- from the 2011 yellowfin Multifan-CL stock assessment, the average spawning stock biomass level corresponding to that time period was identified as a Target Reference Point level to represent the management objective of minimising range contraction; and
- a set of deterministic projections were performed where future fishing conditions were adjusted to achieve a total yellowfin spawning stock biomass level in 2018 consistent with the relevant target biomass levels. The reduction in effort or catch within WCPO purse seine and longline fisheries required to rebuild the stock to those levels by 2018 were identified.

Analysis:

Spatially modelled yellowfin CPUE data over time were examined, using different threshold CPUE levels to identify potential minimum catch rate levels within the southern temperate fisheries - being 2 individuals per 1000 hooks and 3 individuals per 1000 hooks (Figure 1). The shaded area in that figure represents the geographic region in which the threshold CPUE level or greater was achieved. Hence, at a lower threshold CPUE level a greater geographic area is shaded. For each row, the geographic area where the identified minimum catch rates could be achieved contracts over time as the size of the yellowfin population declines. Based on the two threshold catch rate levels selected, two time periods were identified:

- For a threshold of 2 individuals per 1000 hooks, a period of 1996-2000 was selected, representing a period prior to modelled catch rates decreasing notably to the north of New Zealand and across many of the southern SIDS (bottom left panel of Figure 1a).
- For the threshold of 3 individuals per 1000 hooks, the period 1991-1995 was selected, representing a period where the model indicated that this minimum catch rate was still achieved to the north of New Zealand and across many of the EEZs of the southern SIDS (top right panel of Figure 1b).

Results are presented for projections where reductions in catch or effort were taken across all fleets within the WCPO region (excluding 'other' fisheries). For illustration, the time series of total WCPO adult yellowfin biomass is show in Figure 2 for the scenario where total adult biomass recovers to the target equivalent to a catch rate threshold of 3 individuals per 1000 hooks (average total biomass 1991-1995).

Required reductions in fisheries to achieve targets

The overall reductions in catch/effort within both purse seine and longline fisheries in all model regions to achieve the alternative candidate target reference levels are presented in Table 2. Notable reductions are required to achieve the identified catch rate levels by 2018, from around one quarter to achieve the lower CPUE target, to over 50% to achieve the slightly higher target biomass level.

Significant reductions in fisheries would be required to achieve the target reference point levels by 2018. It is noted that if recovery were scheduled over a longer time scale, lower reductions in fishing levels would be required.

Implications for fishery catch rates

We examine the change in 'vulnerable biomass', which represents the yellowfin biomass available to particular gears as defined by their selectivity. This acts as a proxy for future catch rates (Figure 3).

The vulnerable biomass of all gear groups in 2018 had increased notably compared to 2011 levels following the required fishery reductions. Gains were unsurprisingly lower where the lower biomass target (equivalent to 2 individuals/'000 hooks) was reached, and greater where the larger biomass target was achieved.

Tropical longline and purse seine fisheries benefit the most from catch reductions in terms of catch rates. Potential catch rates of these fisheries double where the lower biomass target is achieved by 2018, or increasing by 150% at the larger biomass target.

Temperate fisheries (which include southern PICT fisheries) also experience an increase in vulnerable biomass, by 25 to 40% dependent on the target level achieved.

The benefits for southern PICT longline fleets specifically were similar but slightly lower than that predicted for the temperate fisheries as a whole, with increases of over 20% compared to 2011 levels.

Reductions in fishing to achieve the targets therefore result in notable predicted increases in catch rates in all fisheries. Tropical fisheries in the core yellowfin habitat benefit most, compared to those fisheries in temperate regions. In turn, southern temperate (longline) fisheries, while also benefiting from reductions, benefit less than other temperate fisheries.

Overall, therefore, all fisheries are predicted to benefit through increased catch rates if catch levels are reduced, and further benefits in vulnerable biomass may be seen with projections extended for longer periods. However, notable reductions in catch or effort are required to achieve those benefits within the timescale set. This illustrates the significant trade off that would be faced achieving these example target reference points, between the reductions in effort/catch, the timescale for rebuilding, and the potential for lower costs of capture and greater profitability that result.

It should be noted that if range contraction were occurring - which is not directly incorporated within the projection model - increased benefits for temperate fisheries might be seen. The specific population dynamics that may lead to range contraction should result in a greater potential transfer of fish from the tropics to temperate waters with a recovery of tropical biomass levels.

Discussion points:

- How important are catches of tropical tuna to Coastal fisheries at higher latitudes?
- Is a management objective based on fisheries across the range of stocks appropriate?
- What performance measures are appropriate for such a management objective?
- Given fisheries interactions and potential trade-offs between both purse seine and longline fisheries and tropical and temperate fisheries for yellowfin, what is a desirable approach to achieving any target?
- What considerations are appropriate to determining an ‘extent of the stock’ Target Reference Point and rebuild timescale?
- What mechanism could be used to offset the impacts of a management measures which result in a fishery bearing a disproportionate burden?

Tables and Figures:

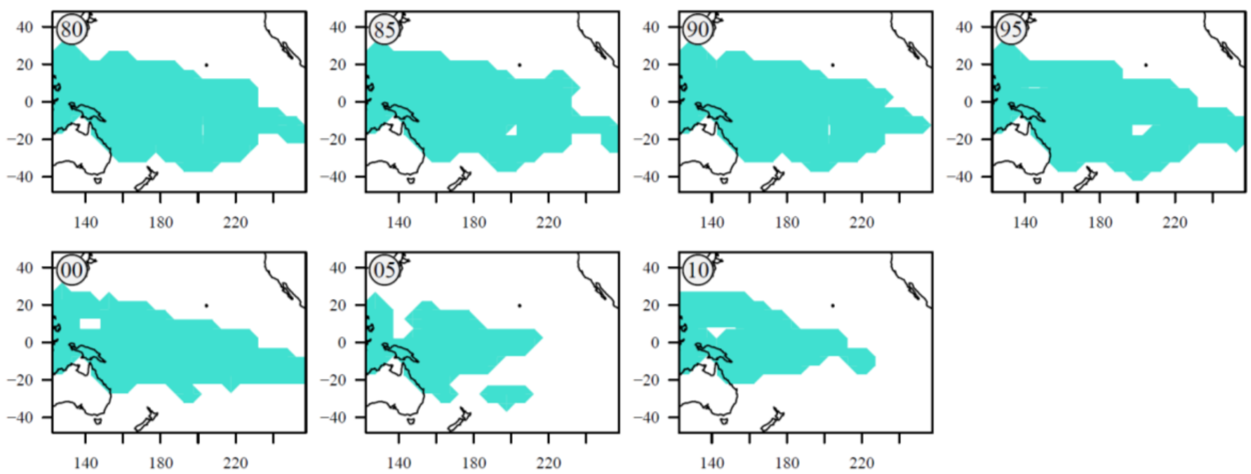
Table 1. Estimated average spawning stock biomass levels across the whole model region, as estimated from the reference case yellowfin stock assessment model, relative to 2006-10 levels.

CPUE threshold (individuals/1000 hooks)	**Period**	**Average total biomass level (target) relative to 2006-10 avg**
3	1991-1995	1.75
2	1996-2000	1.33
	% decline 1991/95 to 2006/10	43%
	% decline 1996/00 to 2006/10	25%

Table 2. Percentage reduction in overall effort/catch within all fisheries exploiting yellowfin, to achieve the alternative target reference levels identified.

CPUE target (individuals/1000 hooks)	**Reduction in total effort/catch required**
3	58%
2	24%

a)



b)

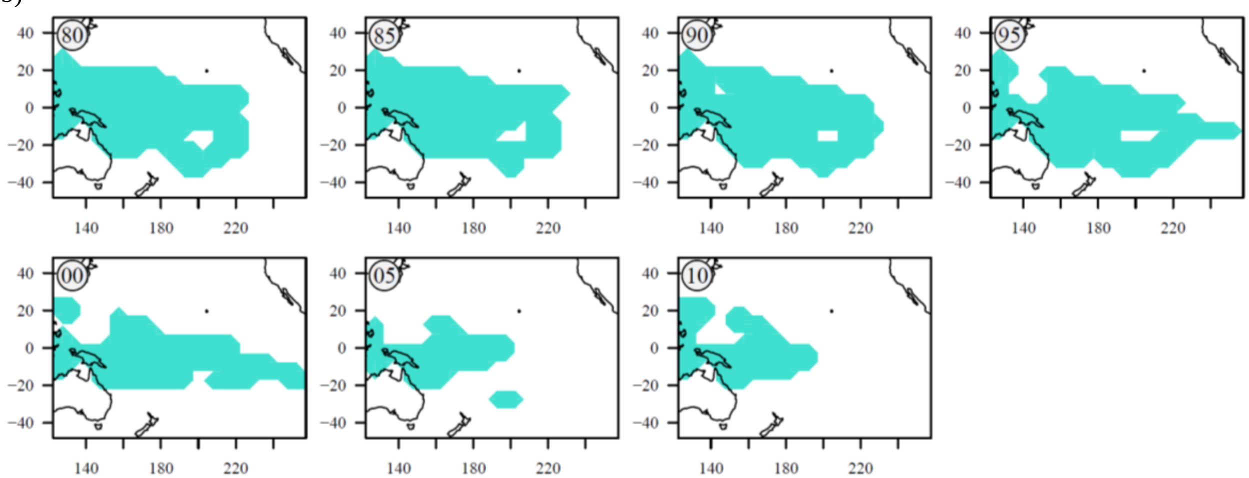


Figure 1. Regions estimated to have a minimum catch rate at the specified threshold level: a) 2 individuals per 1000 hooks; b) 3 individuals per 1000 hooks. Individual panels represent the periods from 1976-1980 (top left panel) to 2006-2010 (bottom right panel).

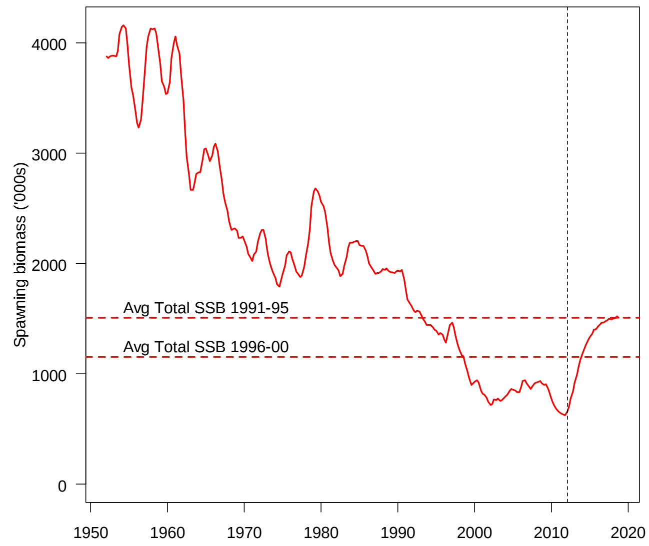


Figure 2. Trajectory of total adult biomass (spawning potential) from the 2011 yellowfin stock assessment and recent fishing (up to 2011; vertical dotted line), and under the projection that recovers the total biomass to the average level over 1991-95. Horizontal dotted lines represent the total biomass averaged over periods 1991-95 and 1996-00.

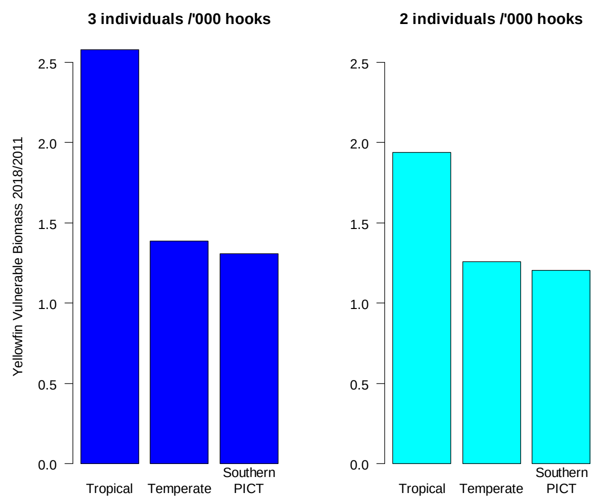


Figure 3. Performance measures of 2018 fishery-specific vulnerable biomass levels (a proxy for catch rates) relative to 2011 levels, for 'tropical' (longline and purse seine), 'temperate' grouped fishing fleets (north and south), and Southern PICT fleets (southerly longline) specifically for each candidate target stock size (presented as the desired CPUE threshold levels).

Annex: Methods (please contact Graham Pilling grahamp@spc.int for further details)

A time series of aggregated 5°x5° catch and effort data from a key longline fleet were modelled to predict historical relative abundance at the scale of the Pacific, and filled the holes in space and time of the existing CPUE data based on some related variables that are available from those areas. Related variables included oceanographic model outputs that covered both fished and unfished cells since 1980 (GODAS ocean analysis model by NOAA). As an example, temperature and year explained 40% of the variation in yellowfin catch rates. The full model related trends in yellowfin tuna catch rates across the Pacific (5°x5° aggregated longline data) to oceanographic covariates, as well as year and quarter (seasonal patterns), latitude and longitude of the 5°x5° cell corresponding to the CPUE data. Temperature at 25 meters and isodepth (the depth of the isothermal layer) were selected as the oceanographic variables that performed best. This model was designed with a flexible structure to cope with the fact that the geographic area covered is large, while trends in catch rates over time are expected to differ between locations. Due to the presence of many zero catch values in fished cells, especially at higher latitudes, the model was fitted in two stages: (1) a first model for the presence or absence of successful (positive) catch when the cell was fished (i.e. a zero catch or positive catch); (2) a second model for the size of the catch rate for those cells where a positive catch had been recorded. The predictions from both stages were then combined and used to predict catch rates for the Pacific over the period 1980-2010 (oceanographic data being available from 1980). If the assumption that catch rates are proportional to fish abundance holds, model predictions should be representative of yellowfin population density patterns over the Pacific since the 1980s.

Deterministic stock projections to the year 2018 (consistent with the timescale for the Tropical Tuna CMM) were used to achieve 2018 total yellowfin spawning stock biomass levels consistent with selected target biomass levels under specific longline catch and purse seine effort scalars, using the 2011 yellowfin stock assessment. Future recruitment was assumed to occur at the level defined by the stock-recruitment relationship, based on the spawning stock size at that time. Other fisheries (pole and line fisheries and those of Indonesia and Philippines) were maintained at 2011 levels. Scalars were applied to 2011 fishery levels.